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Educational effect of 3D applications as a teaching aid for anatomical practice for dental hygiene students

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Abstract: The purpose of this study is to find out effective methodology of anatomical curriculum by comparing the education effects and satisfaction using different teaching tools, plastic model and three-dimensional (3D) application. A survey was conducted on the satisfaction level, understanding, and the usefulness of the tools used in the lectures of the two dental hygiene students groups who used the 3D application and the plastic model respectively. The interest in anatomical structure of the 3D App group was 4.20, which was significantly higher than that of the plastic model group 3.60, and the usefulness of the content of anatomy education was 4.31 in the 3D App group, significantly higher than the plastic model group (P<0.05). It was found that the interest in anatomical structure of students increased by 0.347 when using 3D applications compared to the case without the use (P=0.012) and understanding in anatomical structure and class concentration increased by 0.191, respectively, but these results were marginally significant. We expect that this study serves as a reference for the development and supplementation of anatomy teaching and learning method.

Key words: Anatomical practice, Education, Plastic Model, 3D Application, Dental hygiene student

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Introduction

Head and neck anatomy in the dental hygiene curriculum is the most important process for acquiring the associated clinical skills as it enables proper understanding the structure and function of the oral cavity. It is not only a decisive subject in the successful completion of all curriculum, including the compulsory major courses taught in the upper grades, but it is also a necessary course to acquire effective clinical practice. In addition, the head and neck anatomy is a key element in the basic dental hygiene field, which is the basic knowledge of the national license examination, it is one of the compulsory subject.

Courses for anatomy education are offered in the dental hygiene program under various names such as oral anatomy, head and neck anatomy, and most of them have the subject in the curriculum for first graders [1]. Head and neck anatomy is a hugely unfamiliar subject for first-year students who have no knowledge on medicine and the dental terminology. Students have difficulty in learning the anatomical structure of the oral cavity because they have to learn the structure that is not actually visible by way of relying on the textbook pictures, and it is difficult to properly cultivate the ability to apply to the actual clinical practice under these circumstances.

In order to make up for the problems of the theory-centered class, practice education courses using cadaver are used in the field of healthcare education including medicine and dentistry. The curriculum utilizing cadaver is the ideal way to understand the structure and function of the human

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body more accurately [2]. Because students directly touch and observe the tissues of the body, they can remember them in more detail. In addition, it is the most efficient and useful practice method because it increases understanding of anatomy, enhancing the effectiveness of learning and motivation of learners [3].

Anatomy practice education using cadaver is the most effective and essential method to improve the quality of anatomy education, but its implementation has practical difficulties from changes in curriculum and time and space constraints [4]. This problem is also prominent in the dental hygiene program. Due to the problem of obtaining cadaver for the practice, cadaver practice in the dental hygiene program is practically impossible. Only 38.1% of the dental hygiene school in Korea have cadaver practice education only as a one-off occasion at dental or medical schools [1]. In other universities, it is inevitable to carry out the practice education by means of lecture-based education using textbooks, atlases, and models. Because of this, students complain of difficulty in understanding the anatomical structure and function of the oral cavity, and have difficulty in achieving the goal of anatomy practice education.

In order to address this problem, anatomy instructors are trying to overcome the limitations of unavailability of cadaver anatomy practice by finding new teaching tools and methods to replace cadaver anatomy practice [5]. In the United States and Australia, to tackle this problem, digital technology education such as computer simulation is used as an alternative to improve the quality of education [6]. In Korea, CDs, videos, online contents, and three-dimensional (3D) programs are used as alternatives to address the limitations of anatomical practice education, and efforts are being made to develop new teaching methods using various teaching tools. Of these various efforts, 3D applications that can be used with mobile or tablet devices are drawing attention. The 3D application uses new software, touchscreens and a variety of interfaces to present anatomical information to students in a novel and different way.

It is essential to evaluate students' satisfaction with the practice using various teaching tools, and to grasp the advantages and disadvantages of the various teaching tools including their efficiency, and to use them in education. In this study, we conducted comparative analysis by separate operation of the curriculum with classic teaching tool, that is, the plastic model, and the new teaching tool, the 3D application. The purpose of this study is to find out effective methodology of anatomical curriculum by comparing the education effects and satisfaction using different teaching tools, plastic model and 3D application.

Materials and Methods

Subjects

In this study, we surveyed the dental hygiene students. After explaining the purpose and objectives of the study, the study was conducted on students who were willing to participate in the survey. The study was approved by the Catholic Kwandong University Institutional Review Board (No. CKU-19-01-0310) for the safety and protection of the study subjects. The survey was conducted on two groups. One group consisted of 31 students at B University who took head and neck anatomy class and the associated practice course using a plastic model (plastic model group), while the other group consisted of 41 C university students who took head and neck anatomy class and the associated practice course using the paid version of a 3D application, Complete Anatomy (3D4Medical, Dublin, Ireland) (3D App group).

Methods

This study was carried out by web-based survey method in self-administered method, and preliminary survey was conducted on 20% of the subjects, and the improvements considering the results of the preliminary were reflected, and the revised survey tool was finally selected. A survey was conducted on the satisfaction level, understanding, and the usefulness of the tools used in the lectures of the two groups who used the 3D application and the plastic model respectively. Statistical analysis was performed using SPSS version 20.0 (IBM Corp., Armonk, NY, USA). The general characteristics, the current status of course completion, and the ratio of helpful teaching aids during and after the class were analyzed by the chi-square test for the two groups for which classes were taught using 3D applications and plastic models, respectively. The satisfaction on the education content, interest, understanding and usefulness were scored on a 5-point scale and analyzed with independent samples t test for the mean difference analysis. In addition, in order to investigate the effect of 3D application utilization on students' anatomical education, the enhancement on the degree of interest, improvement of understanding, and concentration improvement were defined as educational effects and set as the outcome variables with 3D application utilization as independent variable. Multivariate

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linear regression was used with age, sex, and the completion of biology and anatomy courses before entering university as covariates. In addition, since significant correlations were observed by the level of student's individual anatomy learning effort, the analysis was conducted excluding students who made no individual efforts in learning anatomy. As statistical determination criteria, the type I error level was set to 0.05, and it was interpreted as marginally significant when the significance probability was between 0.05 and 0.10.

Results

Characteristics of study subjects

For the gender of the subjects in this study, the ratio of female students was high in both groups, with 92.7% in 3D App group and 93.5% in plastic model group. In the two groups, 80.5% and 83.9%, respectively, had experience of taking biology courses before entering the university, showing higher ratio than the students without completing the biology subject. The proportion of students who have completed anatomy-related courses in both groups was 14.6% and 19.4%, respectively, showing higher ratio of students who did not complete the anatomy-related course before (Table 1). There was no significant difference between the two groups in general characteristics.

Tools helpful to understand the anatomical structure

We examined the teaching tools that helped the subjects understand the anatomical structure during the class. When comparing the 3D App group and the plastic model group, the ratio of responding that the lecture was helpful was 83.9% in the plastic model group, which was significantly higher than the 3D App group (P=0.006). Except for the 3D application and the plastic model, the effect of drawing with the training textbook was higher in the 3D App group (26.8%), and the effect of asking questions to the instructor was higher in the plastic model group (P=0.002). Therefore, the proportion of the students in the plastic model group who answered that the instructor's lectures and questions to the instructor helped the learning was significantly higher, indicating that the students were more dependent on the instructor in the plastic model class (Table 2).

Anatomical educational effects of 3D applications and plastic models

Table 3 shows the differences in satisfaction, interest, understanding, and usefulness of anatomy classes between the two groups. The interest in anatomical structure of the 3D App group was 4.20, which was significantly higher than that of the plastic model group 3.60, and the usefulness of the content of anatomy education was 4.31 in the 3D App group,

Table 1. Subject's General characteristics and course completion status of the subjects

	3D App group	Plastic model group	P-value[a]
Age (y)	18.77±0.71	19.12±1.01	0.781
Sex			
Male	3 (7.3)	2 (6.5)	0.886
Female	38 (92.7)	29 (93.5)	
I had experience of taking biology courses before entering the university			
Yes	33 (80.5)	26 (83.9)	0.480
No	8 (19.5)	5 (16.1)	
I had experience of taking anatomy courses before entering the university			
Yes	6 (14.6)	6 (19.4)	0.421
No	35 (85.4)	25 (80.6)	
I made an individual effort in learning anatomy			
Agree	17 (41.5)	17 (54.9)	0.781
Usually	16 (39.0)	10 (32.3)	
Disagree	8 (19.5)	4 (12.9)	

Values are presented as number (%). 3D, three-dimensional. [a]P-value by chi-square test.

Table 2. The most helpful tool to understand the anatomical structure during class

Category	3D App group	Plastic model group	P-value[a]
Lecture	22 (53.7)	26 (83.9)	0.006
Textbook	22 (53.7)	17 (54.8)	0.921
General plastic model	11 (26.8)	28 (90.3)	<0.001
Drawing using the practice textbook	11 (26.8)	2 (6.5)	0.026
3D application	36 (87.8)	4 (12.9)	<0.001
Anatomy video	6 (14.6)	1 (3.2)	0.106
Internet search	6 (14.6)	1 (3.2)	0.106
Discussion with course mates	3 (7.3)	1 (3.2)	0.453
Questions to the instructor	5 (12.2)	14 (45.2)	0.002

Values are presented as number (%). 3D, three-dimensional. [a]P-value by chi-square test.

Table 3. 3D anatomical educational effects of 3D applications and plastic models

	3D App group	Plastic model group	P-value
Satisfaction on the content of anatomy education	4.01±0.73	4.10±0.93	0.535
Interest in anatomical structure	4.20±0.90	3.60±0.87	0.021
Understanding in anatomical structure	3.86±0.86	4.02±0.74	0.286
Usefulness of the content of anatomy education	4.31±0.70	3.98±0.74	0.010

P-value by independent samples t test. 3D, three-dimensional.

Table 4. Effects of 3D application utilization on the educational effect of anatomy in students

Education effect of 3D application in the anatomy class	Unstandardized regression coefficient	Standard error	Standardized regression coefficient (95% CI)	*P*-value
Increase in the interest in anatomical structure	0.347	0.137	0.230 (0.076 to 0.617)	0.012
Enhancement in understanding of anatomical structure	0.191	0.112	0.144 (–0.031 to 0.412)	0.091
Improvement in the concentration during anatomy class	0.191	0.118	0.138 (–0.041 to 0.424)	0.106

All multi-variable linear regression models adjusting for age, sex, biology and anatomy course completion before entrance of university. Reference variable: the use of plastic anatomic model. 3D, three-dimensional; CI, confidence interval.

significantly higher than the plastic model group ($P<0.05$).

Effects of 3D application utilization on the educational effect of anatomy in students

In order to examine the effect of 3D application utilization on students' anatomical educational effect, increase in the interest in anatomical structure, enhancement in understanding of anatomical structure, and improvement in the concentration during the anatomy class were defined as educational effects and set as the outcome variables, and 3D application utilization was set as independent variables. The results of the multivariate linear regression analysis are shown in Table 4. It was found that the interest in anatomical structure of students increased by 0.347 when using 3D applications compared to the case without the use ($P=0.012$) and understanding in anatomical structure and class concentration increased by 0.191, respectively, but these results were marginally significant.

Discussion

Head and neck anatomy is an essential curriculum in training dental hygienists with necessary expertise and skills. Ideally, cadaver practice should be combined with theoretical education for proper understanding of anatomical knowledge. However, most university use drawings on practice textbooks and plastic models to run training courses. Thus, the majority of anatomy instructors at the dental hygiene school find it difficult to teach the students to understand accurate 3D information with limited resources available. In order to address these problems and increase the effectiveness of anatomical education, it is necessary to introduce various teaching tools and try new teaching methods in the practice course.

In this study, 3D applications and plastic models were used as educational aids and the satisfaction and educational effects of the two groups for which anatomical curriculum was run were quantitatively confirmed through a survey and comparative analysis was performed on the results.

Plastic models have been the most commonly used teaching tool for a long time, and 3D applications are the teaching tools that are increasingly used in recent years for more effective practice training. Both groups were dental hygiene students, who completed head and neck anatomy and the associated practice courses while they were in the first grade. The curriculum, contents, and instructors of both groups were identical. All students of two groups took same head and neck anatomy class.

The two groups were examined in terms of the teaching tools that helped them understand anatomical structures. In the group using the plastic model, there were significantly more responses saying that the lectures and the questions to the instructor were helpful than the group using the 3D application, indicating that students were more dependent on instructors teaching the course. In the group that operated the class using the 3D application, there were significantly more responses saying that the drawing using the practice textbook were helpful. During the class, the process of operating the 3D application to study anatomical structure and positional relationship was performed by the instructor demonstrating with a beam projector along with the lectures. It was difficult for every student to operate the application directly on their own while learning, but they learned in the perspective of the observer only. In order to resolve such issue, a drawing practice in which the students can directly take part was carried out, and it is thought that this has brought about positive effects.

Plastic models have been used as a conventional tool for anatomy training. As a result of surveying on the pros and cons of the plastic model, the biggest advantage from the responses was that the anatomical structure can be observed up close and the students could directly touch it to stimulate the sense of touch. Also, the responses mentioned that there was a sense of reality because it can be observed at actual size. However, there were negative responses that it was difficult to assemble after disassembling the model and the process after the course was complicated, the parts of the model were easily broken, and for small parts, they could be easily lost.

As for the 3d application that is being applied recently, the

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biggest advantages from the responses was that 3D observation, which was difficult to realize from the two-dimensional figures from the textbook became possible and that they could observe the rotational images and the cross sections of the images. On the other hand, the disadvantageous aspect was that the 3D images that the students observed during the class could not be used after the class for individual learning. There were also differences between the mobile version and tablet version as well as between paid version and free version and this was also a disappointment for students. Purchasing a tablet PC and paid software can be a burden for students due to high initial costs.

According to the results of this study, the educational effect by the 3D application was significantly higher, especially for students with a lot of individual anatomical learning time. If students can use 3D application in addition to the class time, their interests, satisfaction and competencies on anatomical understanding can be enhanced, and for this, supports such as providing the tablet PC for learning or renting service are required.

As mobile and tablet devices become popular, it is a global trend to use them for learning. More and more medical schools around the world are providing tablet devices as an essential tool to support student learning and using them in education, and the use of software (3D applications) is increasing accordingly. Using 3D technology, the positional relationship of anatomical structures can be observed from various view and directions, and it is helpful in making students understand anatomical structures and supplementing the existing anatomy training [7, 8].

In this study, the proportion of students using 3D applications in individual learning time after class was high (46.3% and 22.6%, respectively). Therefore, despite the cost-related difficulties including the purchase of devices such as tablet PCs and the purchase of paid software, their scope of application is expected to increase gradually.

This study was conducted for a short time only for a limited number of students, so the results cannot be generalized. And since it was used only in skeletal system lectures among the entire curriculum, it cannot be concluded that it would show the same usefulness in learning of other systems. However, the positive effects on skeletal system education have indicated its potential impact on future anatomy training, and it is thought that 3D applications should be actively considered as a teaching aid. In 3D applications, animations such as muscle movement and blood flow, which are difficult to implement in plastic models, can be reproduced, further increasing is usefulness. We expect that this study serves as a reference for the development and supplementation of anatomy teaching and learning method.

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Conceptualization: DYC. Data acquisition: JEH. Data analysis or interpretation: JEH. Drafting of the manuscript: DYC. Critical revision of the manuscript: DYC. Approval of the final version of the manuscript: all authors.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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